

DRIVING CONTROL DEVICE FOR ACTUATOR

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a driving control device for an actuator which controls the driving of the actuator for opening and closing an air mix door of an air conditioning device for a vehicle, for example.

Description of the Prior Art

10 Conventionally, there has been known a driving control device for an actuator which controls the driving of the actuator for opening and closing an intake door.

 This type of actuator driving control device comprises a driving circuit for driving a DC electric motor and a driving control circuit for
15 controlling the rotation of the electric motor by controlling the driving circuit.

 The driving control circuit compares a detected signal of a detecting device which detects the rotation position of the intake door and a targeted value, and controls the driving circuit so as to position
20 the intake door in a targeted position.

 The driving circuit of the actuator driving control device is composed of an H bridge circuit 100 for rotating the DC electric motor in normal and reverse directions. The H bridge circuit 100 is composed of four MOS type transistors Tr1 to Tr4, as shown in FIG. 6, for example.

25 In the H bridge circuit, it has been known that at least two transistors of the four transistors are driven by PWM control (for example, reference to Japanese Patent 3199722).

However, in this actuator driving control device, when the motor is actuated or is stopped, the output of the electric motor is rapidly changed by ON/OFF operations (turning on and/or turning off) of the MOS transistors, Tr1 to Tr4, of the H bridge circuit 100.

5 Consequently, there has been a problem that noise is generated by backlash of a gear, and the noise is offensive to ears, because especially in recent years, a sound of an engine has been reduced, and an interior of a car has been becoming noiseless.

10 SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a driving control device for an actuator capable of preventing a generation of noise when an electric motor is actuated or is stopped.

15 In order to achieve above object, an driving control device for an actuator according to the present invention comprises a driving device to drive an actuator having an electric motor and a driving control device to control the rotation of the electric motor by controlling the driving device, and the driving device comprises an H bridge circuit constructed by a switching semiconductor element, and rotates the electric motor in
20 normal and reverse directions by turning on and/or off the switching semiconductor element.

25 The driving control device conducts activating and/or stopping the electric motor by applying a PWM signal to the switching element constructing the lower arm of the H bridge circuit, and regenerative braking is applied to the electric motor by applying the PWM signal to the switching semiconductor element constructing the lower arm.

 The driving control device may be constructed to be capable of

selecting a mode for applying the PWM signal to the switching semiconductor element constructing the lower arm or a mode for applying the driving pulse.

5 The driving control device may comprise a function for switching to apply the driving pulse when a radio is turned on and to apply the PWM signal when the radio is turned off.

Moreover, the driving control device can comprise a construction for switching the mode to the mode for applying the driving pulse when a targeted torque is not obtained even if the PWM signal is applied.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a construction of an air conditioning device for a vehicle in which a driving control device of an electric motor type actuator according to the present invention is applied.

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FIG. 2 is a view showing an example of the electric motor type actuator according to the present invention.

FIG. 3 is a block diagram of the driving control device of the electric motor type actuator.

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FIG. 4 is a circuit diagram showing an enlarged H bridge circuit and an enlarged actuator driving control circuit according to the present invention.

FIG. 5 is a timing chart describing soft start and soft stop of an electric motor.

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FIG. 6 is a circuit diagram showing an example of conventional H bridge circuit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, an embodiment of an air conditioning device for a vehicle to which a driving control device for an actuator according to the present invention is applied will be described with reference to the accompanying drawings.

In FIG. 1, reference numeral 1 denotes a body of air conditioning device for a vehicle. As well as a general air conditioning device for a vehicle, the body 1 is constructed by an intake unit 2 for selectively taking in outside air or inside air, a cooling unit 3 for cooling the intake air, and a heater unit 4 for blowing out the blended air in a vehicle after the intake air is blended and the temperature of the intake air is adjusted.

The intake unit 2 is provided with an outside air intake 5 for taking in outside air and an inside air intake 6 for taking in inside air. The connection portion of the intakes 5 and 6 is provided with a rotatable intake door (driven mechanism) 7 for adjusting the ratios of the outside air and the inside air which are taken in the unit. The intake door 7 is rotated by an electric motor type actuator (not shown).

The intake door 7 is rotated by transmitting the rotation of an actuator lever 30L to the intake door 7 shown in FIG. 1 through a link mechanism (not shown). The rotation position of the intake door 7 is detected by a potentiometer 31 as described below.

As shown in FIG. 1, the intake unit 2 comprises a fan 10 which is rotated at a predetermined speed by a fan motor 9. Each outside air or inside air is selectively taken from the outside air intake 5 or the inside air intake 6 by the rotation of the fan 10, and in accordance with the position of the intake door 7. Moreover, the rotation speed of the fan 10

is changed by modulation of an applied voltage to the fan motor 9, so that the volume of air to be blown inside a vehicle is adjusted. When the intake door 7 is positioned in A as shown in FIG. 1, an outside air entry (FRE) is adopted, and when the intake door 7 is positioned in B as shown in FIG. 1, an inside air circulation (REC) is adopted.

An evaporator 11 for constructing a refrigeration cycle is installed in the cleaning unit 3. Refrigerant is supplied to the evaporator 11 by activating a compressor (not shown), and the intake air is cooled down by a heat exchange with the refrigerant.

A heat core 12 for circulating engine cooling water is installed in the heater unit 4. An air mix door 13 for adjusting the ratio between the volume of air which is passed through the heat core 12 and the volume of air which is bypassed the heat core 12 is rotatably disposed in the upstream side of the heat core 12.

The air mix door 13 is rotated by an electric motor type actuator 30A shown in FIG. 2 through a link mechanism (not shown). A mixture ratio between the warm air which is heated by the heat exchange with the engine cooling water after passing through the heat core 12 and unheated cool air which is bypassed the heat core 12 is changed, so that the temperature of the air which is blown inside the vehicle is adjusted.

The adjusted air is supplied inside the vehicle from any blower of a defrost blower 15, a vent blower 16, and a foot blower 17. These blowers 15 to 17 are respectively provided with a defrost door 18, a vent door 19, and a foot door 20 rotatably.

These doors 18 to 20 are rotated by an electric motor type actuator (not shown) through a link mechanism (not shown). A blowing mode is arbitrarily set up by combining an opening and closing condition

of each blower 15 to 17.

FIG. 2 is a view showing an example of an electric motor type actuator according to the present invention. The electric motor type actuator 30A comprises an electric motor 30, a worm 30c installed in a power output shaft 30b of the electric motor 30, a reduction gear train mechanism 30e which is engaged with the worm 30c, and the actuator lever 30L which is rotated through the worm 30c and the reduction gear train mechanism 30e.

FIG. 3 is a block diagram showing the construction of a control unit (a driving control device for an actuator) 40 which controls the actuator 30A and the like.

The control unit 40 is provided with a power source circuit of 5V 41, a circuit for protecting an internal power source 42, a first LIN input circuit, a second LIN output circuit, a communication ID input setup circuit 80, and a LIN communication processing circuit 45.

The power source circuit of 5V 41 generates 5V power source by receiving the electric power from a power source of battery + B. The internal power source protecting circuit 42 protects the 5V power source circuit 41. The first LIN input circuit receives data from a main control unit (not shown). The second LIN output circuit sends data to the main control unit (not shown). The communication ID input setup circuit 80 sets up an ID cord for identifying each control unit 40. The LIN communication processing circuit 45 extracts data having the same ID cord with the ID cord which is set up by the communication ID input setup circuit 80 from the data received by the LIN input circuit 43. The LIN communication processing circuit 45 adds the ID cord set up by the ID input setup circuit 80 to required data, and then sends the data to the

LIN output circuit 44. At this point, the LIN communication processing is a communication in line with ISO9141 standard, and its communication method is UART.

Furthermore, the control unit 40 comprises a data latch circuit 46,
5 a D/A converter 47, an input circuit 48, a comparator 49, and an actuator driving output control circuit (driving control device) 50, and an H bridge circuit (driving device) 51.

The data latch circuit 46 maintains the data extracted by the LIN communication processing circuit 45. The D/A converter 47 conducts
10 D/A conversion for the data maintained by the data latch circuit 46. The input circuit 48 inputs the output voltage of the potentiometer 31 which detects an opening of the intake door 7. The comparator 49 compares the output voltage of the potentiometer 31 which is supplied through the input circuit 48 and the voltage which is output from the
15 D/A converter 47, and then outputs an output signal in accordance with the difference of those voltages. The actuator driving output control circuit 50 generates PWM signal, which controls the electric motor, based on the output signal of the comparator 49, and outputs the PWM signal. The H bridge circuit 51 drives the electric motor 30 based on the
20 PWM signal which is output from the actuator driving output control circuit 50.

The control unit 40 is also provided with an over-current detection circuit 53, an over-voltage detection circuit 54, and an over-temperature detection circuit 55. The over-current detection
25 circuit 53 generates an over-current detection output when the current supplied to the electric motor 30 through the H bridge circuit 51 exceeds a predetermined acceptable value. The over-voltage detection circuit 53

generates an over-current detection output when the voltage (voltage of power source of battery +B) applied to the electric motor 30e exceeds a predetermined acceptable value. The over-temperature detection circuit 55 observes a temperature of the electric motor 30 based on a detected output of a temperature detection element (not shown) such as a thermistor installed in the electric motor 30, and generates an over-temperature detection output when a temperature of the electric motor 30 exceeds a predetermined acceptable temperature.

When the over-current, the over-voltage, and the over-temperature are detected by these detection circuits 53, 54, and 55, the H bridge circuit 51 and the electric motor 30 are adopted to be protected by stopping the driving of the electric motor 30.

FIG. 4 is a partly enlarged view of the H bridge circuit and the actuator driving control circuit. The H bridge circuit 51 is constructed by first and second transistors, Tr1 and Tr2, which construct an upper arm, a transistor Tr3 which constructs one of the lower arms, and a transistor Tr4 which constructs the other lower arm.

The actuator driving output control circuit 50 judges about whether or not the driving of the electric motor 30 is required based on the output voltage of the comparator 49. In other words, when the output voltage of the comparator 49 is higher than a reference voltage by a predetermined value, the actuator driving output control circuit 50 determines that the door should be driven in an opening direction by normally driving the electric motor 30. When the output voltage of the comparator 49 is lower than the reference voltage by a predetermined value, the actuator driving output control circuit 50 determines that the door should be driven in a closing direction by reversely driving the

electric motor 30. When the output voltage of the comparator 49 is within a predetermined value range with respect to the reference voltage, the actuator driving output control circuit 50 determines that the electric motor 30 should be stopped.

5 While the driving of the electric motor 30 is stopped, the actuator driving output control circuit 50 outputs a driving pulse to the transistors Tr3 and Tr4 such that the transistor Tr3 is turned on, and the transistor Tr4 is turned on. In FIG. 5, a reference numeral T denotes a zone that the driving pulse is input in the transistors Tr3 and
10 Tr4.

As shown in FIG. 5, when the electric motor 30 is driven in the normal direction, a driving pulse P1 is output from a driving signal output terminal Q1 to the transistor Tr1, and the transistors Tr4 and Tr3 are turned off once. Next, PWM signal is output from a driving signal
15 output terminal Q4 to the transistor Tr4. The PWM signal is controlled such that a duty ratio of the PWM signal is increased by 8% per second during the time t_a from 0% to 100% adopting a targeted value of rotation frequency as 100%.

When the transistor Tr4 is turned on, an electric current shown
20 in arrow A1 of FIG. 4 is flowed into the electric motor 30, and the rotation frequency of the electric motor 30 is gradually increased during the time t_a , after that the electric motor 30 is rotated by a constant rotation frequency.

Next, when the actuator driving output control circuit 50
25 determines that the electric motor 30 should be stopped, PWM signal in which a duty ratio is decreased from 100% to 0% by 8% per second is output from the driving signal output terminal Q4 to the transistor Tr4

during time t_b . The rotation frequency of the electric motor 30 is thereby decreased. At this point, the electric current flowed into the positive terminal of the electric motor 30 becomes a reference numeral G1 of FIG. 5.

5 While the actuator driving output control circuit 50 turns off the transistor Tr1 for softly applying a regeneration brake to the electric motor 30, the actuator driving outputs control circuit 50 outputs the PWM signal in which the duty ratio is increased from 0% to 100% from the driving signal output terminals Q3 and Q4 to the transistors Tr3 and
10 Tr4 during the time t_b . The electric current in the direction of arrow A2 is thereby flowed into the electric motor 30 based on an electromotive force accompanying the inertia rotation of the electric motor 30, and the regeneration brake is softly applied to the electric motor 30, and then the rotation of the electric motor is stopped.

15 As shown in FIG. 5, when the electric motor 30 is driven in the reverse direction, a driving pulse P2 is output from the driving signal output terminal Q2 to the transistor Tr2, and the transistors Tr3 and Tr4 are turned off once. Next, PWM signal is output from the driving signal output terminal Q3 to the transistor Tr3. The PWM signal is controlled
20 such that the duty ratio of PWM signal is increased by 8% per second during the time t_a from 0% to 100% adopting a targeted value of revolution frequency as 100%.

 When the transistor Tr3 is turned on, an electric current shown in arrow B1 is flowed into the electric motor 30, and the rotation
25 frequency of the electric motor 30 is gradually increased during the time t_a . After that the electric motor 30 is rotated in the reverse direction at a constant rotation frequency.

Next, when the actuator driving output control circuit 50 determines that the electric motor 30 should be stopped, the PWM signal in which the duty ratio is decreased from 100% to 0% by 8% per second is output from the driving signal output terminal Q3 to the transistor Tr3 during the time tb. The rotation frequency of the electric motor 30 is thereby decreased. At this point, the electric current flowed into the negative terminal of the electric motor 30 becomes a reference numeral G2 of FIG. 5.

While the actuator driving output control circuit 50 turns off the transistor Tr2 for softly applying a regeneration brake to the electric motor 30, the actuator driving output control circuit 50 outputs the PWM signal in which the duty ratio is increased from 0% to 100% from the driving signal output terminals Q3 and Q4 to the transistors Tr3 and Tr4 during the time tb.

Consequently, the electric current in the direction of the arrow B2 in FIG. 4 is flowed into the electric motor 30 based on an electromotive force accompanying the inertia rotation of the electric motor 30, and the regeneration brake is softly applied to the electric motor 30, and then the rotation of the electric motor is stopped.

In this embodiment of the present invention, when the electric motor is activated, the rotation frequency of the electric motor 30 is adopted to increase from 0% to 100%, and when the electric motor is stopped, the rotation frequency of the electric motor 30 is adopted to decrease from 100% to 0%, so that the noise caused by backlash of a gear is reduced by using the PWM signal.

However, when avoiding a generation of radio noise caused by the PWM signal rather than reducing the noise caused by backlash of a gear,

a bit for controlling ON/OFF of the PWM signal (turning on and turning off of the PWM signal) is provided in the LIN communication signal, and the actuator driving output control circuit 50 may determine the ON/OFF of the PWM signal. With the above described construction, when the PWM signal is ON, the actuator driving output control circuit 50 adopts a mode for applying the PWM signal, and when the PWM signal is OFF, the actuator driving output control circuit 50 adopts a mode for applying a driving pulse in which the transistors Tr3 and Tr4 are turned on and are turned off without being late.

The actuator driving output control circuit 50 may comprise a function for switching to apply the driving pulse when a radio is turned on and to apply the PWM signal when the radio is turned off.

The actuator driving output control circuit 50 may comprise a function for switching the mode to the mode for applying the driving pulse when a targeted torque cannot be obtained even if the PWM signal is applied.

As described above, according to the present invention, an electric motor can be started softly and can be stopped softly, so that when the electric motor is activated or is stopped, the noise generated by a power transmission mechanism such as a reduction mechanism or a driven mechanism such as an opening and closing mechanism can be reduced without changing a circuit construction drastically.